

# Intercomparison between Aura MLS and ground-based millimeter-wave observations of stratospheric O<sub>3</sub> and HNO<sub>3</sub> from Thule



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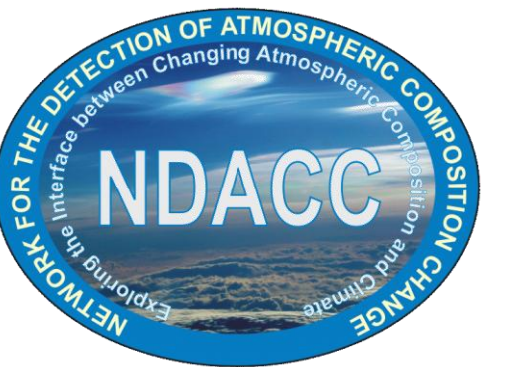
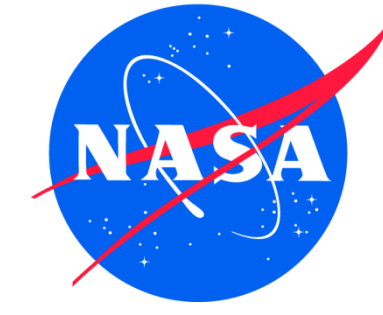
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In view of a growing need for long-term data sets of stratospheric constituents, in January 2009 a Ground-Based Millimeter-wave Spectrometer was installed at the NDACC Arctic station of Thule Air Base (76.5 N, 68.8 W), Greenland, in order to track the long- and short-term interactions between the changing climate and the seasonal processes tied to the ozone depletion phenomenon. Since then three winter campaigns were carried out from Thule during the period January-March 2009, 2010 and 2011. Observations of O<sub>3</sub>, HNO<sub>3</sub>, CO and N<sub>2</sub>O were performed, mostly on a daily basis, except during periods characterized by poor weather conditions.

In this study we compare GBMS stratospheric O<sub>3</sub> and HNO<sub>3</sub> measurements obtained during 2010 and 2011 winter campaigns with colocated satellite observations from the Aura Microwave Limb Sounder (MLS) experiment.

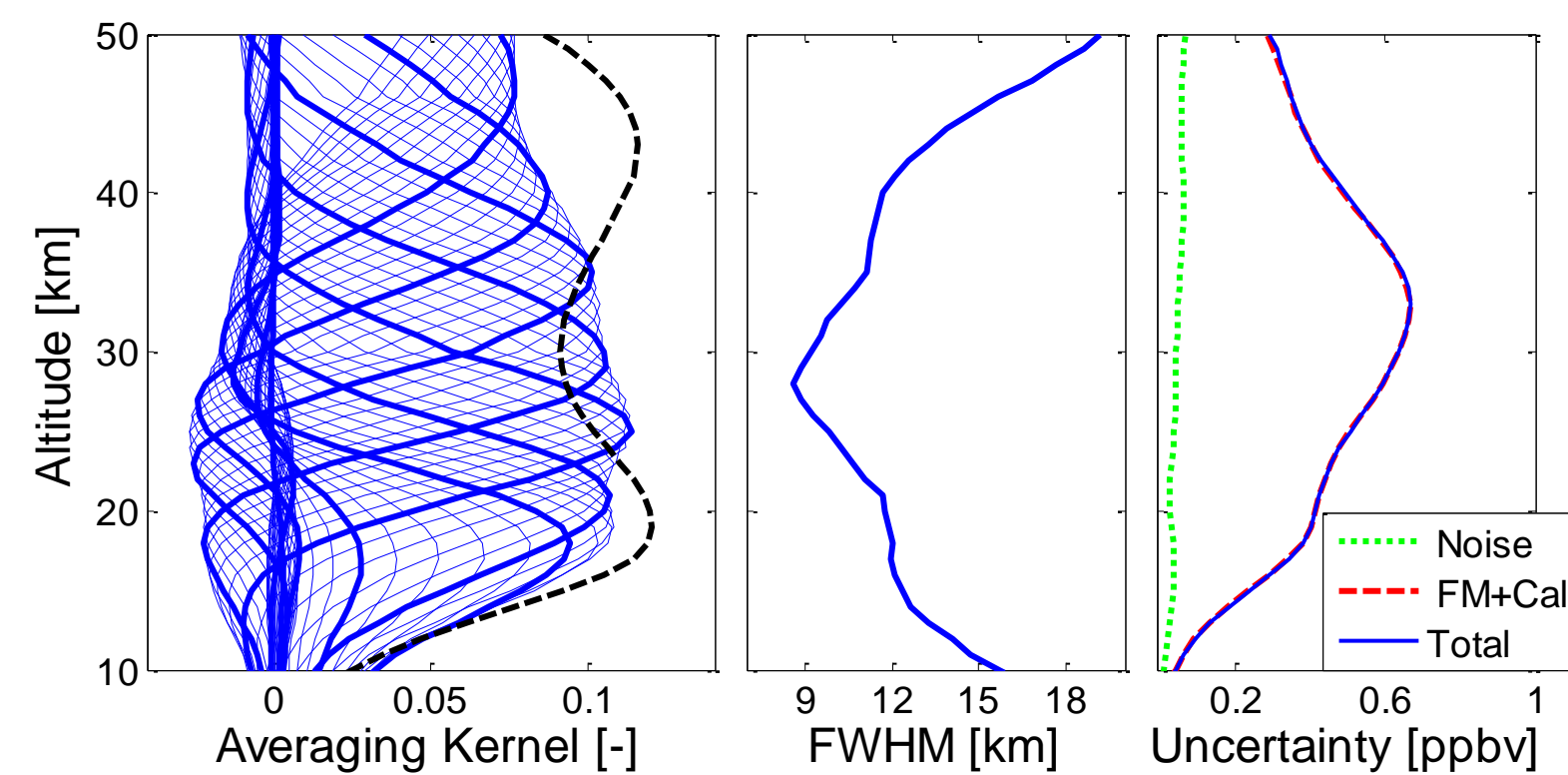
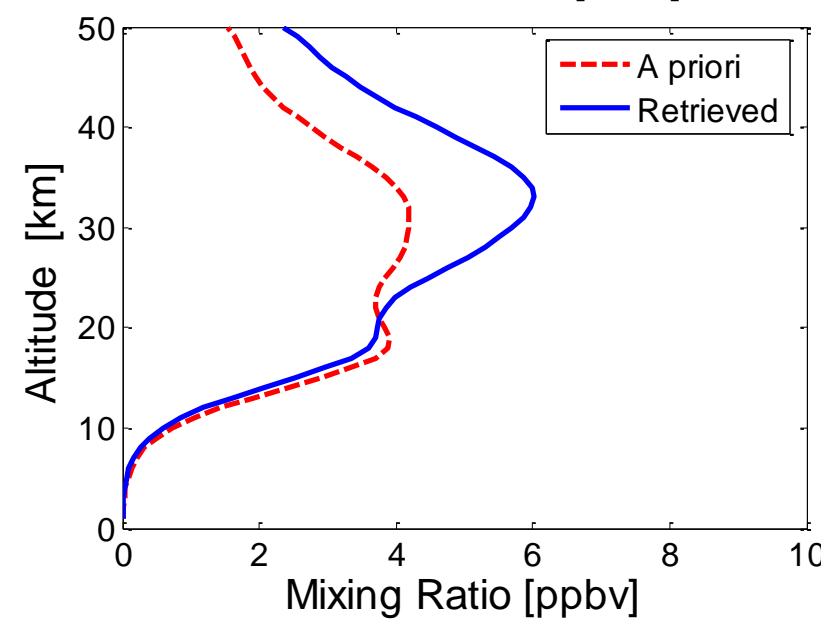
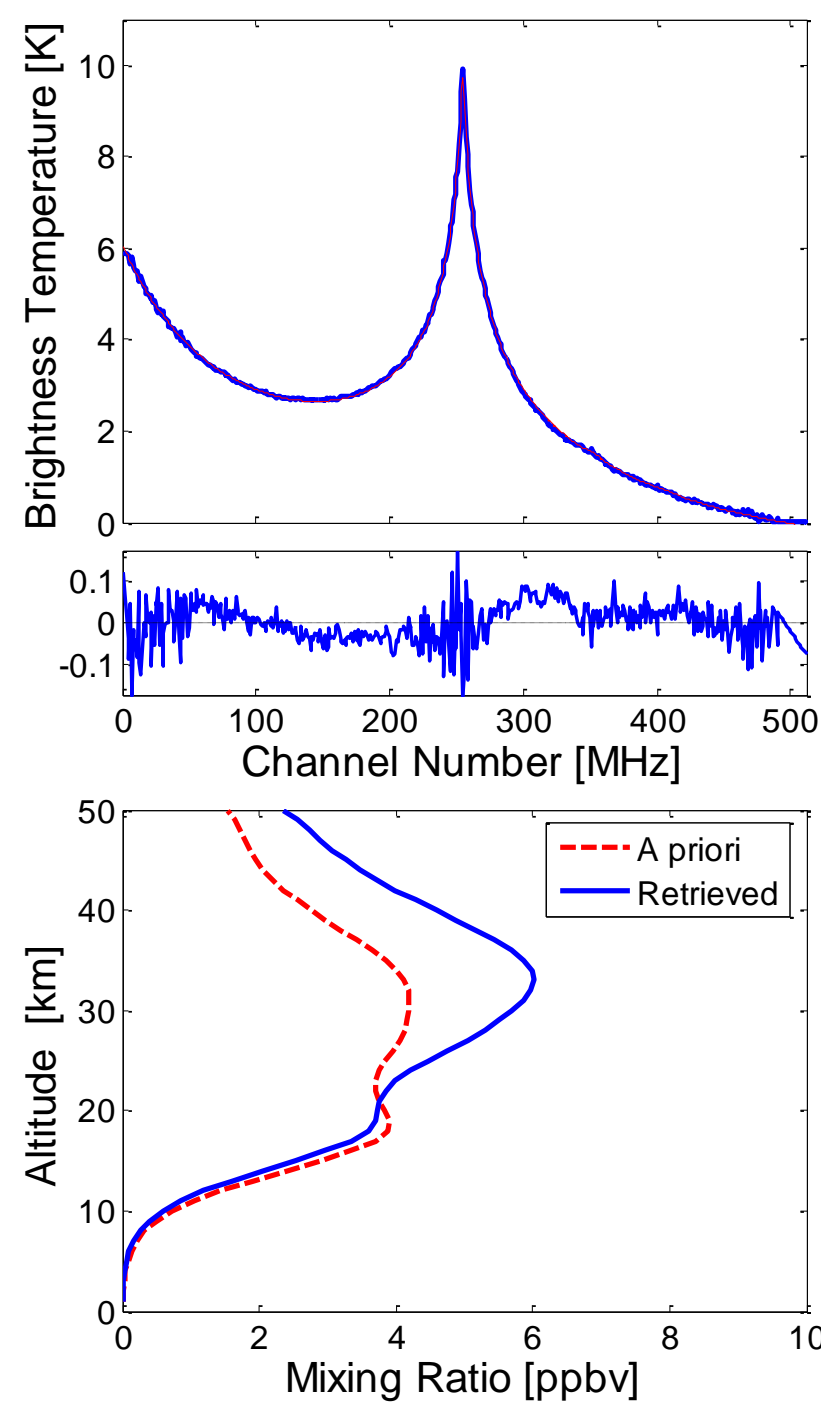
## Ground-Based Millimeter-wave Spectrometer (GBMS)



- Heterodyne spectrometer (tunable between 230-280 GHz) observing rotational emission spectra of stratospheric trace gases [de Zafra, 1995]
- Bandwidth: 600 MHz

### GBMS O<sub>3</sub> observations

- Obtained observing the pure rotational transition lines at 276.923 GHz (superimposed on the wing of a second ozone line) or at 264.926 GHz.
- Retrievals considered reliable in the altitude range 15-45 km (where sensitivity  $\sim 1.0 \pm 0.2$ )
- Vertical resolution (FWHM of the kernels):  $\sim 10$ -12 km.
- $1\sigma$  uncertainty on the retrieved profile (due to uncertainties on forward model parameters, instrumental calibration and spectral noise): 11%. [di Biagio et al., 2010]

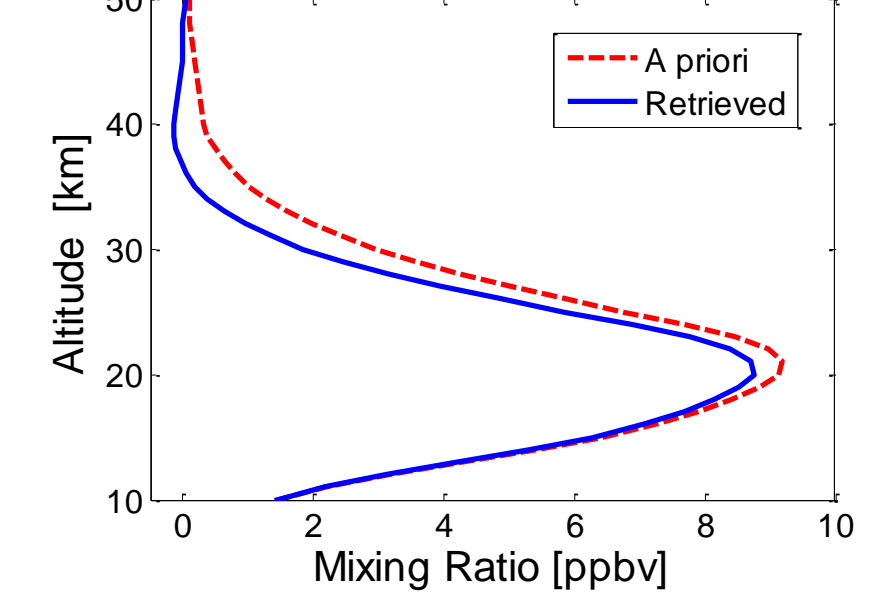
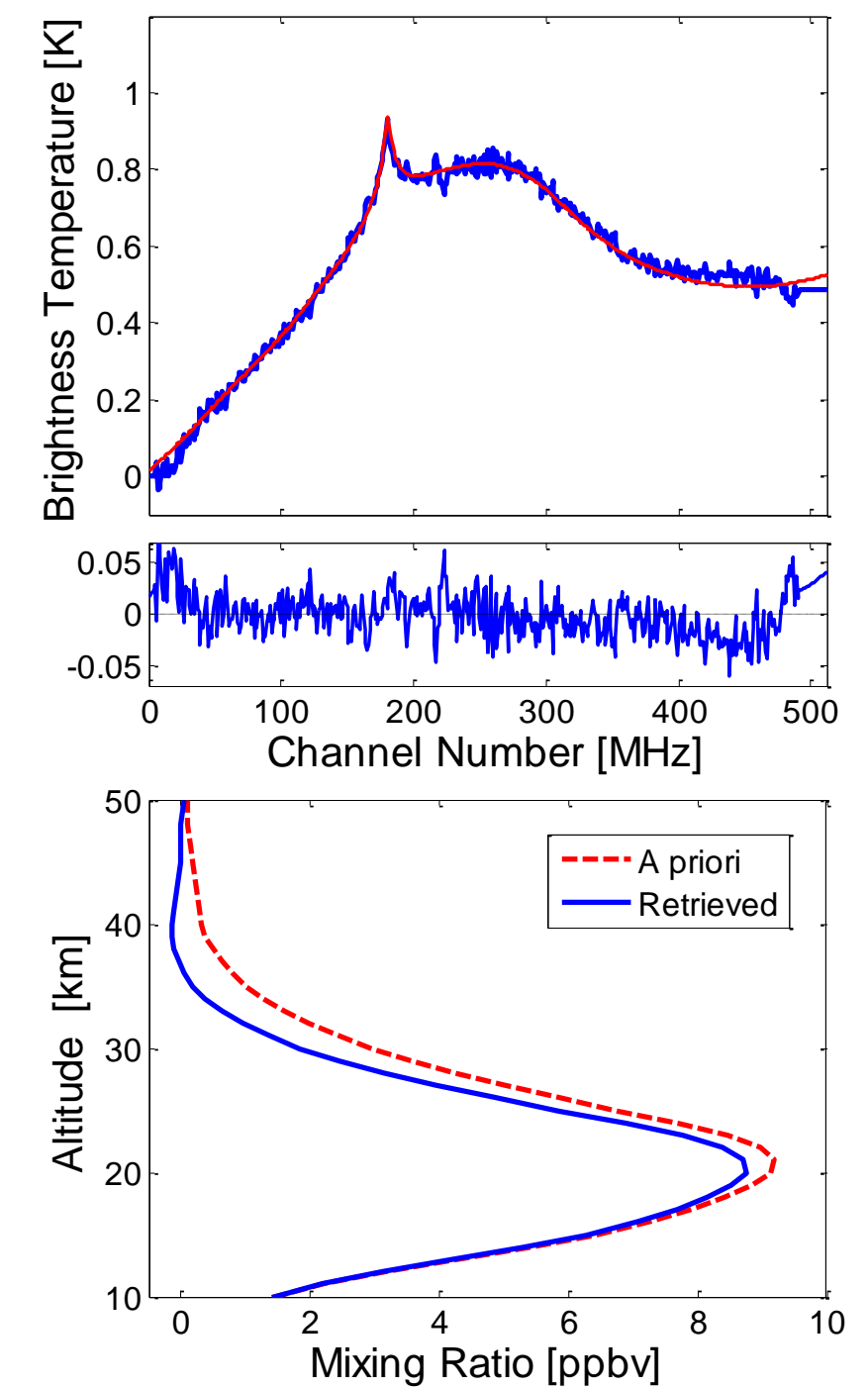
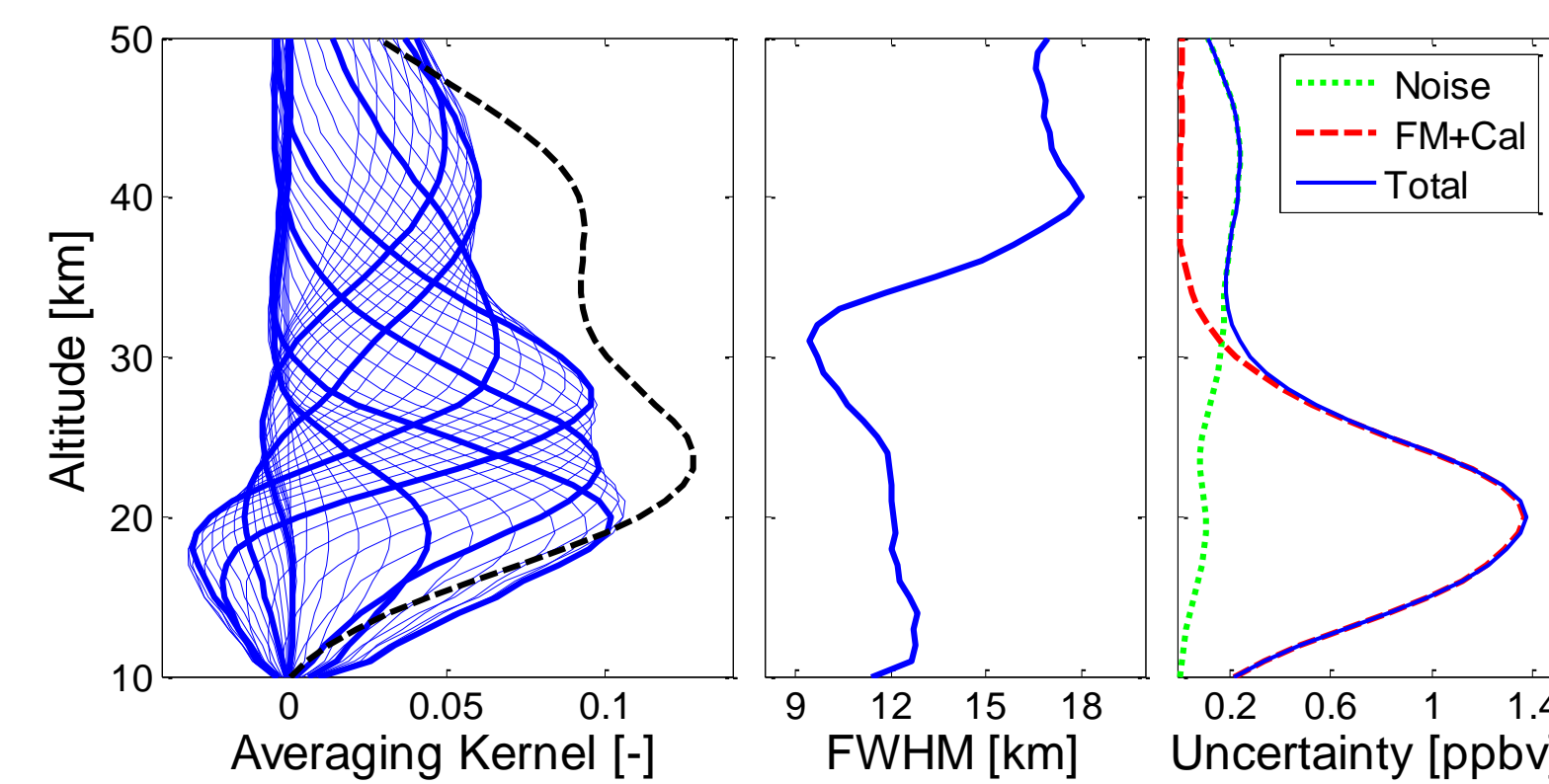


- Spectral resolution : 1.176 MHz (maximum resolution of 65 kHz used only for mesospheric studies)
- Deconvolution technique (to retrieve mixing ratio vertical profiles from the emission spectra): Optimal Estimation Method [Rodgers, 2000]

### GBMS HNO<sub>3</sub> observations

- Composite spectrum characterized by a cluster of emission lines centered at 269.210 GHz superimposed to an ozone line.
- Vertical range where inversions are considered reliable: 18-42 km
- Vertical resolution: 12-18 km.
- $1\sigma$  uncertainty: the larger of 15% or 0.3 ppbv.

[Fiorucci et al., 2011]



## EOS Aura Microwave Limb Sounder

- Launched in July 2004 into a sun-synchronous near-polar orbit aboard the Aura satellite.

- Observes thermal microwave emission lines of many chemical species using five broad spectral regions between 118 GHz and 2.5 THz.

### Ozone

- Vertical range recommended for scientific use: 261 to 0.02 hPa.
- Vertical resolution:  $\sim 2.5$ -5.5 km. [Froidevaux et al., 2008]

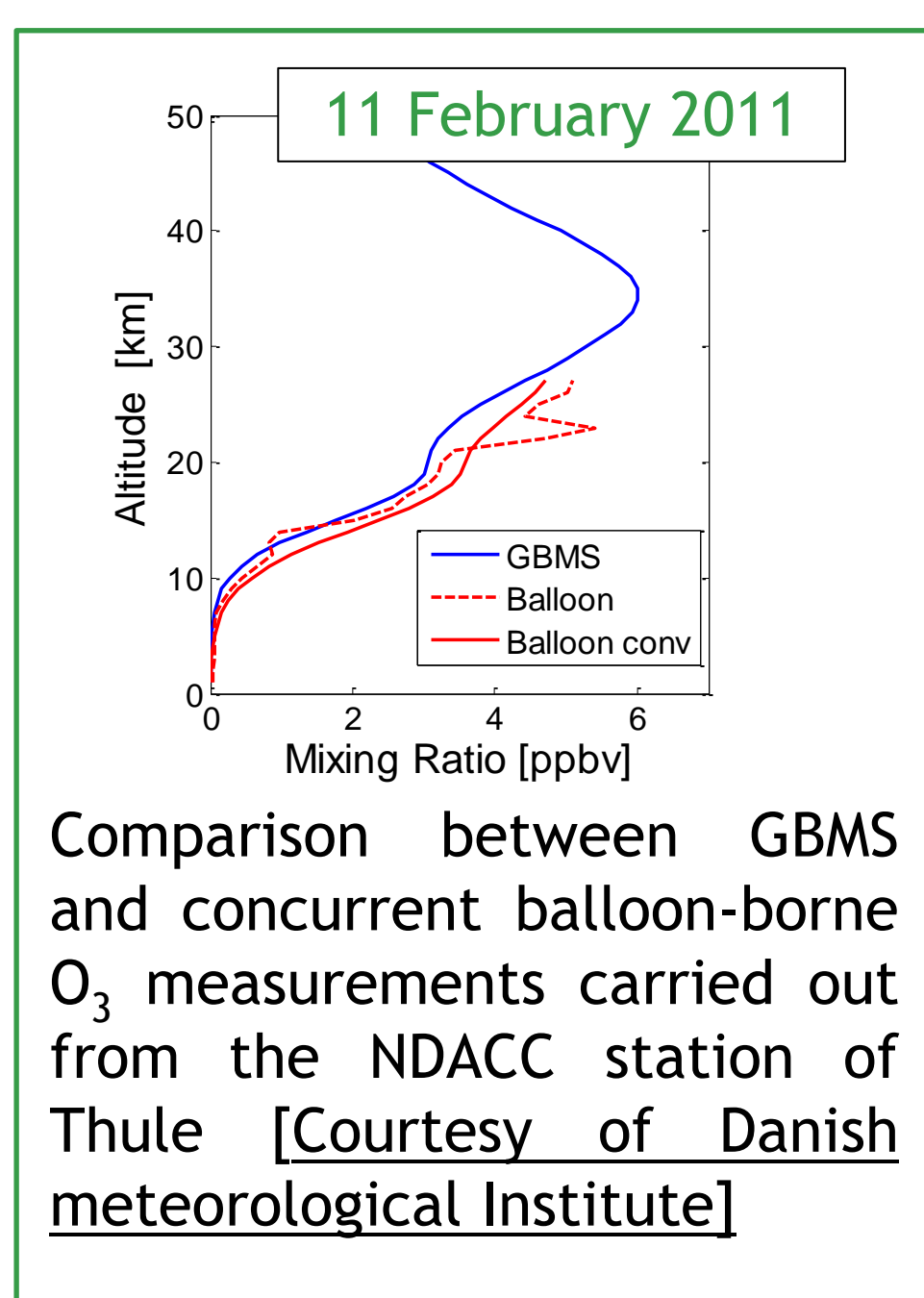
### Nitric Acid

- Vertical range recommended for scientific studies : 215 to 1.5 hPa.
- Vertical resolution:  $\sim 3$ -5 km. [Santee et al., 2007].



## GBMS - MLS intercomparison

### O<sub>3</sub> comparison

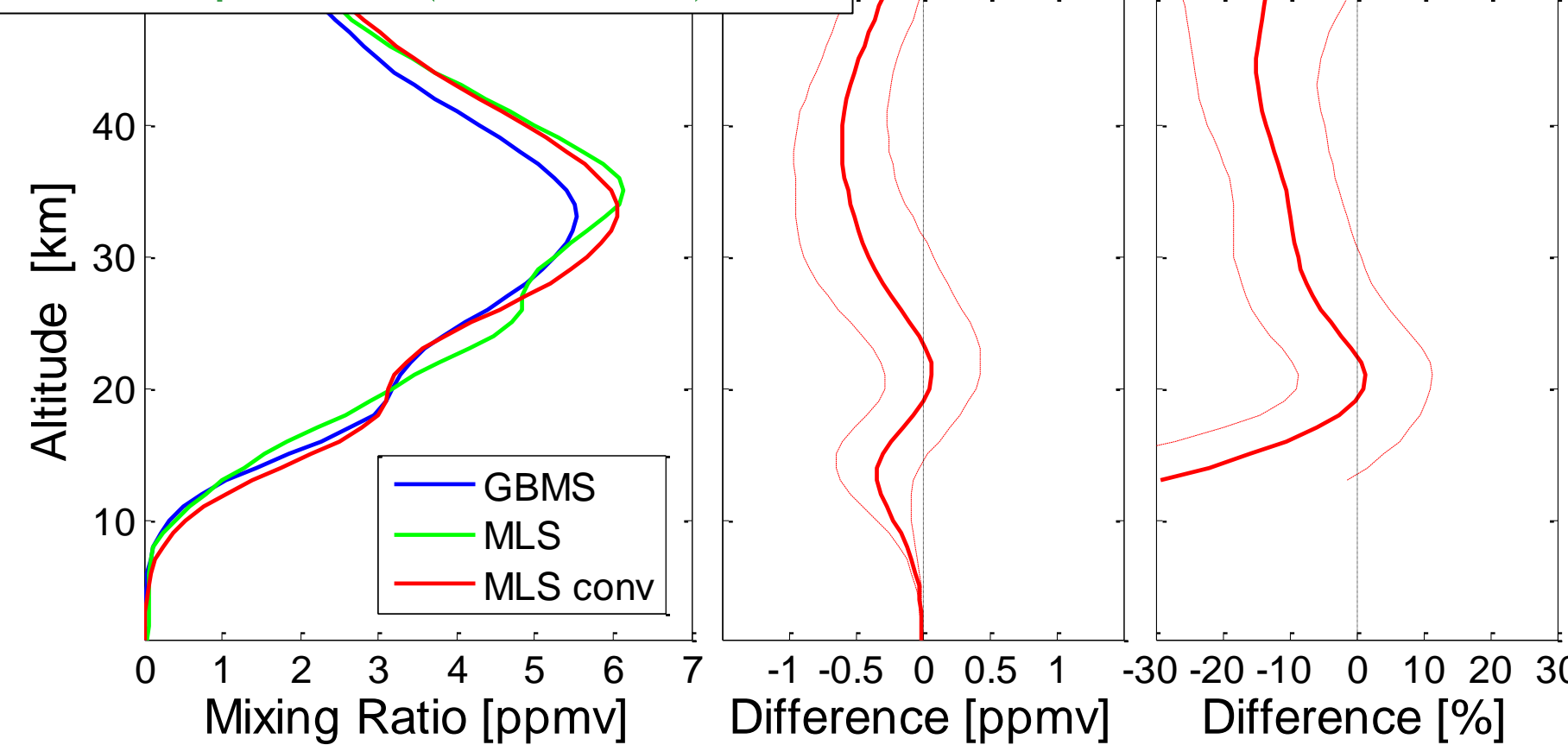


Comparison between GBMS and concurrent balloon-borne O<sub>3</sub> measurements carried out from the NDACC station of Thule [Courtesy of Danish meteorological Institute]

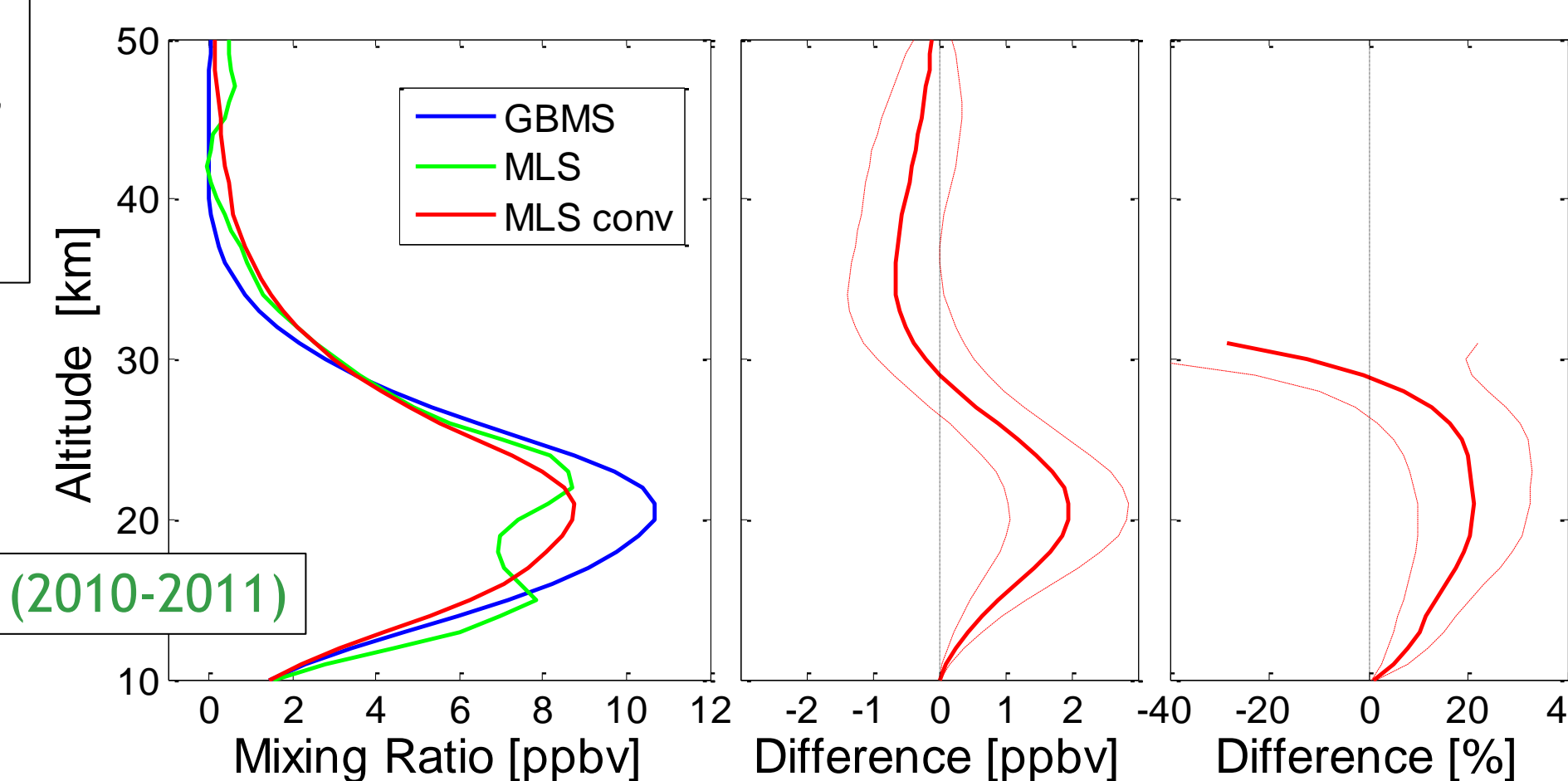
### Coincidence criteria (for both O<sub>3</sub> and HNO<sub>3</sub> datasets):

Each GBMS observation is compared to the closest MLS profile (in time), with coincidence criteria of  $\pm 8^\circ$  longitude,  $\pm 1^\circ$  latitude and  $\pm 6$  h.

### Mean profiles (2010-2011)



### HNO<sub>3</sub> comparison



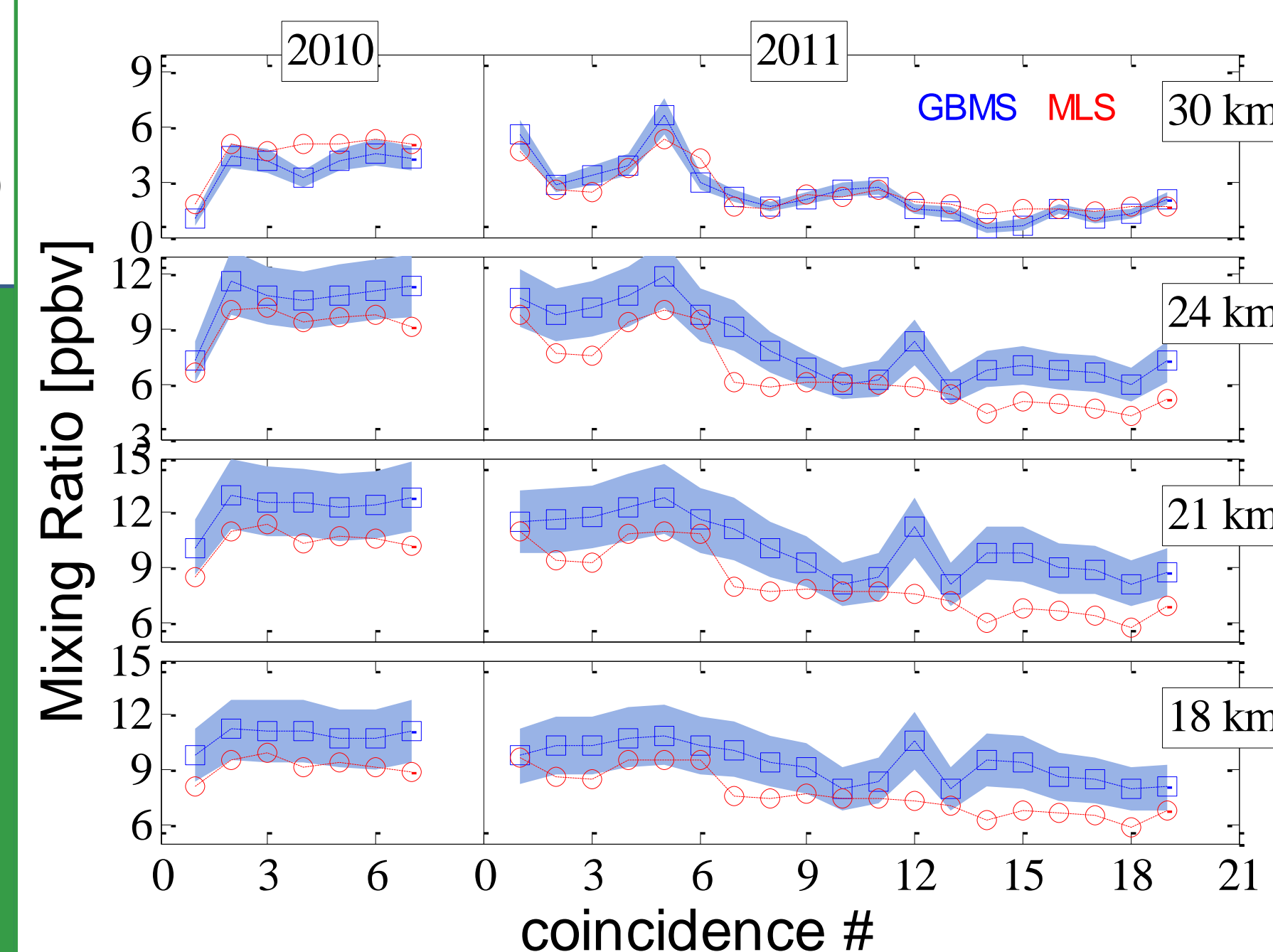
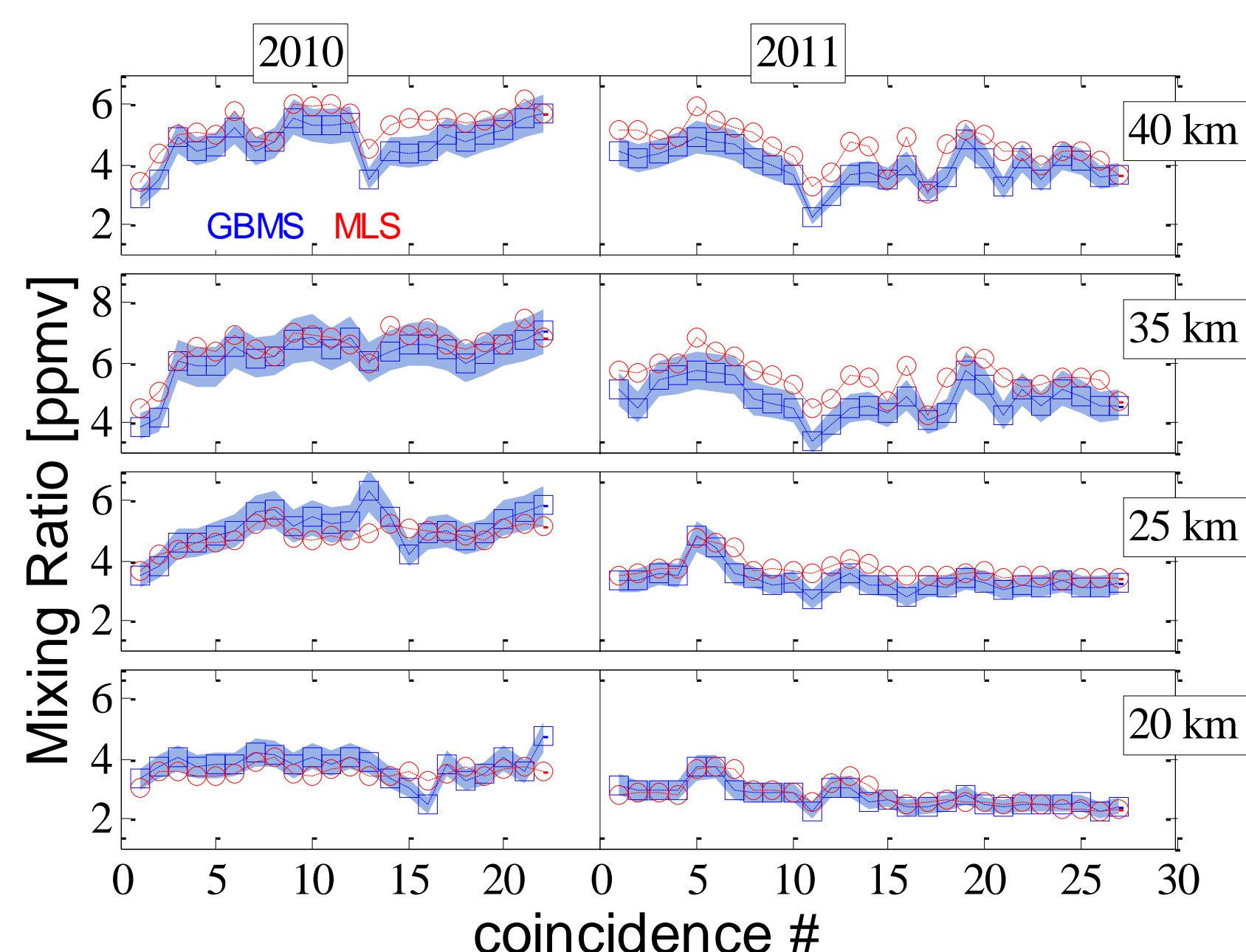
### Conclusions:

- GBMS HNO<sub>3</sub> measurements are larger than those obtained with MLS by about 2 ppbv ( $\sim 20\%$ ) near the profile peak.
- Time series show that GBMS and MLS data are correlated well. Moreover differences between ground-based and satellite observations are systematic and consistent in 2010 and 2011.

### Conclusions:

- GBMS O<sub>3</sub> measurements show a fairly good agreement with ozonsonde and MLS data (as for the satellite data see both average profiles and time series).
- GBMS O<sub>3</sub> measurements are very well correlated with the satellite data at all levels.
- GBMS O<sub>3</sub> values display a small low bias ( $\sim 10\%$ ) in the upper stratosphere.
- Time series show slight differences between 2010 and 2011 GBMS/MLS O<sub>3</sub> comparisons (especially at 35 km). These differences are under investigation (very different stratospheric conditions in 2011 with respect to 2010?)

- Ozonsonde and MLS profiles (higher resolution) have to be "convolved" using the GBMS Averaging Kernels before the comparison.



### References

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